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A two-layer cavity flow model to study interactions beneath ice shelves off the coast of West Antarctica.

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Observational studies have shown that ice shelves off the coast of West Antarctica in the Amunsden Sea area have experienced rapid thinning during the 1990s (Shepherd et al., 2002; Shepherd et al., 2004). In particular, it is believed that oceanographic changes in the Amundsen Sea are responsible for the thinning and acceleration of Pine Island Glacier. An earlier study looking at melt rates generated by a plume model beneath the ice shelf in Pine Island Bay suggested that there was a strong feedback mechanism between the plume and topography of the ice shelf underside near the grounding line (Payne et al., 2007). The influence of ocean properties on the melt rates could not, however, be fully investigated by the simple plume model because it assumes that the ambient ocean is stationary and whose properties do not vary horizontally.

We have modified the above 2D plume model to consist of two-layers; the upper one represents the buoyant, melt-water rich plume and the other represents the circulating ambient ocean water. The addition of an active ambient layer to the 2D model allows ocean properties at the ice shelf front to advect around the cavity. This new model will provide spatial patterns of basal melt rates that will include both the effects of the geometry of the cavity beneath an ice shelf and changes in ocean properties at the shelf's front.

We have developed a simple 2D model so that it can be coupled to an ice sheet model. Momentum of the cavity flow is governed by geostrophic balance modified by a linear drag law and is solved using the rigid lid streamfunction method. Interactions between the layers are parameterised through the entrainmment rate, which depends on the relative velocities, thicknesses and densities of the layers and can be positive or negative.

The model will be applied to the Pine Island Ice Shelf. Results from early simulations with realistic topography of the underside of the the shelf and a flat bedrock using parameter values used by Payne et al. (2007) suggested that melt rates are concentrated close to the grounding line where the slope of the underside of the shelf is greatest and they are around 50 m/yr.

Payne, A. J., P. R. Holland, A. P. Shepherd, I. C. Rutt, A. Jenkins and I. Joughin. 2007. Numerical modeling of ocean-ice interactions under Pine Island Bay's ice shelf. J. Geophys. Res., 112, C10019, doi:10.1029/2006JC003733.
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